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Characterization of strawberry (*Fragaria* × *ananassa*) genotypes based upon the morphological and biochemical quality attributes grown in south-western Punjab

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The strawberry (*Fragaria* × *ananassa* Duch), scientifically classified as a dicotyledonous and octaploid (2n=8x=56), is a perennial herb that grows close to the ground and is cultivated in a wide range of agricultural regions worldwide. The domesticated strawberry originates from France and belongs to the Fragaria genus, which comprises 23 spp. within the Rosaceae family (Mathieu *et al.* 2009). Beyond their sensory appeal, strawberry offer a plethora of nutritional benefits that make them a healthy addition to any diet. The strawberry also serves as an excellent source of vitamin A and vitamin C and could be consumed as fresh or in processed form. The objective of breeding programme is linked with the farmer's interest in new varietal characteristics of the fruit such as yield potential, quality resistance to biotic and abiotic stresses, longer shelf-life and its suitability to particular environment through the evaluation of germplasm collection. The evaluation of genotypes in terms of fruit quality is an important parameter both for fresh and processed fruits (Schwieterman *et al.* 2014). Quality breeding programme needs a germplasm with different fruit characteristics, that can be evaluated by morphological and biochemical methods. Also, there is a lack of data on the characterization of strawberry grown in south-western Punjab. So, the present study was planned to identify the superior strawberry genotypes based on morphological and biochemical traits. The study will give a better idea to plant breeders for selecting the right genotypes for future quality breeding in strawberry.

The present study was carried out during 2022–2023 at Punjab Agricultural University, Regional Research Station, Bathinda (30°11'8"N; 74°56'52"E), Punjab to identify superior strawberry genotypes based on morphological and biochemical traits grown under south-western Punjab conditions. Twenty uniform genotypes of strawberry were procured from Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir. The experiment was conducted in a randomized block design (RBD), replicated thrice. The total numbers of plants/replication were 30 which were spaced at 30 cm × 30 cm. Drip tapes with a flow rate of 1.2 litre/h was used for localized irrigation for each experimental unit. Soil moisture content was monitored at 20 cm depth using tensiometers. When soil moisture was found to below 20 kPa, only then irrigation was performed.

The measurement of fruit length and fruit diameter was taken using digital Vernier calliper. The total number of fruits/plant was determined by counting when the fruits reached maturity. A random selection of 10 fruits from each plot was utilised for measuring the weight of the fruits. Total soluble solids (TSS) (ºBrix) was determined using hand refractometer, while Vitamin C was performed by Hussain *et al.* (2014) method. The concentration of vitamin C is expressed in mg/100 g of fresh weight (FW). The total phenolic content (TPC) was estimated spectrophotometrically using the Folin-Ciocalteu reagent (Hatami *et al.* 2014). The results were expressed in mg/g of fresh weight (FW). The total monomeric anthocyanin content was estimated using the *p*H differential method (Lee *et al.* 2005). The concentration is expressed in mg of Cyanidin-3-Glucoside Equivalent per 100 g of fresh weight (FW). The statistical character analysis for each observed trait was carried out by using MSexcel, CPCSI software. Data was analysed by analysis of variation (ANOVA) and mean were separated by Duncan's multiple comparison range test $P \leq 0.05$.

Morphological analysis of fresh fruits: The yield and yield contributing characters are the important goals that can be attained by selecting and evaluating high-yielding varieties with quality fruits. Therefore, studies about these crucial traits are necessary for the successful cultivation of strawberries.

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The number of fruits/plant, fruit weight, fruit length, fruit diameter, and fruit yield were significantly different among 20 strawberry genotypes (Table 1). The number of fruits/plant ranged from (9.67–16.67). The genotype Black More produced the highest number of fruits/plant (16.67) and the minimum was found in cultivar Fairfox (9.67). The present outcome is in the same trend with the findings of Singh (2016), who reported maximum fruit count of 13.8 and 12.3 in Chandler and Camarosa strawberry genotypes respectively under Ludhiana conditions. The significant variation in fruit count might be associated with variation in the adaptability of varieties under investigation in the prevailing agro-climatic conditions and the management practices adopted for an experiment (Khammayom *et al.* 2022). The other reason for increase in the quantity of fruits/plant could be the accumulation of more starch, carbohydrates, and photosynthates in them as per the findings of Jan *et al.* (2021).

By measuring the fruit diameter and fruit length, the size and shape index can be calculated to identify the differences between varieties without any error. The fruit diameter varied from (16.77–33.90 mm) and was higher in genotype Camarosa (33.90 mm). The fruit length on the other hand was higher in genotype Douglas (39.01 mm). Kumar *et al.* (2012) and Jan *et al.* (2021) reported the average strawberry fruit diameter in the range of 18.78–33.93 mm, which is consistent with the findings of the current experiment.

The fruit yield is directly associated with both the average fruit weight and the number of fruits per plant. The average berry weight varied between 6.46 g in Fairfox to 17.34 g in 'Douglas' and the differences between the genotypes were found to be significant. The variation in fruit weight may be due to the photoperiod light intensity and temperature conditions as per previous reports of Gupta (2021). The highest yield was recorded in cultivar Douglas (287.12 g/plant) which was significantly higher than those observed in other studied genotypes and the lowest yield was noted in cultivar Fairfox (60.64 g/plant). The results were justified by the reports of Rahman (2011), who observed significant variation in strawberry yield, varying between 129.85 g and 442.50 g. The results published by Khammayom *et al.* (2022) also follow the present study's findings.

Biochemical analysis of the fresh fruits: The variability in biochemical composition of different strawberry

Table 1 Morphological analysis of different strawberry genotypes

Genotype	Number of fruits/ plants	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	Fruit yield/ plants (g)
Catskill	14.67^{abcde}	29.20^{j}	17.26^{m}	9.89^{efg}	145.53^{gh}
Nabila	12.67^{efgh}	33.15^{g}	23.17^{i}	8.93^{fgh}	113.03^{i}
Ofra	12.33^{fgh}	24.64^{l}	18.21^{l}	7.17^{hi}	88.56^{kl}
Selva	14.33^{bcdef}	26.30^{k}	20.59^{k}	8.20^{ghi}	117.26^{i}
Red Coat	11.00^{hi}	29.26^{j}	16.77^{n}	10.53^{def}	115.50^{i}
Oso Grande	11.67^{ghi}	35.34^{d}	23.90^{g}	8.37^{ghi}	98.28^{ik}
Majesty	14.67^{abcde}	34.27^{f}	22.05^{j}	11.37^{de}	167.58^{e}
Camarosa	15.37^{abcd}	38.65^{ab}	33.90^{a}	16.47^{ab}	252.61^{b}
13-B	10.67^{hi}	35.41^{d}	24.14^{g}	8.00^{hi}	85.69^{i}
Jutogh Special	15.98^{ab}	37.56^{c}	30.55^{b}	15.55^{bc}	248.00^{bc}
Fairfox	9.67^{i}	23.92^{m}	17.15^{m}	6.46^{i}	60.64^{m}
Katrain Sweet	14.70^{abcde}	34.89^{e}	23.34^{hi}	15.14^{bc}	221.81^{d}
Missionary	13.33^{defg}	34.8^{e}	24.59^{f}	12.27^{d}	163.59^{ef}
Dilpasand	14.33^{bcdef}	32.21^{h}	23.49^{h}	10.77^{de}	154.44^{fg}
Larson	13.67^{cdefg}	34.05^{f}	26.29^{e}	7.93^{hi}	108.23^{ij}
Douglas	16.56^{a}	39.01^{a}	29.70^{c}	17.34^{a}	287.12^{a}
Black More	16.67^{a}	31.12^{i}	28.06^{d}	8.20^{ghi}	136.69^{h}
Anthena	12.67^{efgh}	38.36^{b}	22.07^{j}	11.97^{d}	152.40^{g}
Chandler	15.00^{abcd}	35.70^{d}	24.09^{g}	14.08^{c}	239.06^{c}
Winter Dawn	15.67^{abc}	32.43^{h}	20.45^{k}	15.22^{bc}	238.50^{c}
CD at 5%	1.82	0.38	0.29	1.16	10.32
CV (%)	8.01	0.69	0.75	8.76	3.77

Mean values within a column with different superscripts are significantly different at $P \leq 0.05$.

Table 2 Variability among different cultivars of strawberry genotypes for fruit quality characters

Genotype	TSS (^{o}Brix)	Vitamin C (mg/ 100 g)	Phenolic content (mg/100 g)	Anthoc yanin (mg/100 g)	Total sugars (mg/100 g)
Catskill	8.90^{cdef}	54.72^{b}	380.85^{b}	65.88^{n}	6.37^{c}
Nabila	8.21^{efg}	54.37^{bc}	371.79^{c}	81.84^{g}	5.73^{g}
Ofra	8.52^{def}	57.91^{a}	281.40^{i}	75.05^{j}	5.93^{ef}
Selva	9.00^{bcde}	45.94^{f}	266.43^{j}	86.52^{d}	6.12^{d}
Red Coat	8.53^{def}	56.82^{a}	391.29^{a}	69.16^{l}	5.80^{fg}
Oso Grande	9.52^{abc}	48.79^{e}	373.41^{c}	75.36^{j}	5.95^{def}
Majesty	8.55^{def}	51.18^{d}	266.47^{j}	85.13^{e}	5.55^{h}
Camarosa	9.27^{bcd}	57.53^{a}	329.89^{f}	89.03^{ab}	7.40^{a}
13-B	8.12^{fg}	43.66^{g}	293.42^{h}	79.39^{h}	5.27^{j}
Jutogh Special	9.78^{ab}	48.21^{e}	356.86^{d}	88.28^{bc}	6.50^{c}
Fairfox	6.93^{hi}	46.04^{f}	373.54^{c}	75.65^{ij}	5.23^{j}
Katrain Sweet	8.27^{efg}	27.39^{i}	358.65^{d}	66.48^{mn}	6.08^{de}
Missionary	8.03^{fg}	45.46^{fg}	289.42^{h}	72.12^{k}	5.47^{hi}
Dilpasand	6.47^{i}	54.61^{b}	327.6^{f}	88.79^{ab}	5.23^{j}
Larson	9.77^{ab}	29.08^{i}	289.75^{h}	83.71^{f}	6.88^{b}
Douglas	9.54^{abc}	41.34^{h}	310.28^{g}	89.55^{a}	5.33^{ij}
Black More	7.59^{gh}	52.13^{d}	344.27^{e}	87.24^{cd}	5.47^{hi}
Anthena	6.47^{i}	56.98^{a}	347.96^{e}	67.49^{m}	5.31^{ij}
Chandler	8.26^{efg}	57.48^{a}	306.35^{g}	76.75^{i}	6.10^{de}
Winter Dawn	10.27^{a}	52.54^{cd}	348.24^{e}	86.50^{d}	7.53^{a}
CD at 5%	0.75	1.92	6.28	1.17	0.15
CV (%)	5.34	2.37	1.15	0.89	1.56

Mean values within a column with different superscripts are significantly different at $P \leq 0.05$

TSS, Total soluble solids.

genotypes is given in Table 2. The results showed the highest TSS (10.27 °B) and total sugars (7.53 g) in the Winter Dawn genotype whereas the lowest was recorded in the genotype Anthena (Table 2). The results obtained in the present study were in tune with the findings of Tanuja and Rana (2019) who also reported TSS (9.67–13.20°B) in ripe berries. The highest ascorbic acid content was observed in genotype Ofra (57.91 mg/100 g) and the lowest was in 'Larson' (29.08 mg/100 g). The results agree with the studies of Kumar *et al.* (2020) who also found the same results in Chandler genotype. The highest phenolic content was recorded in genotype Red Coat (391.29 mg/100 g), and the lowest in genotype Selva (266.43 mg/100 g). Our results were similar with the study of Dzhanfezova *et al.* (2020) who recorded (320.0 mg/100 g) phenolic content in variety Elsanta. Among the genotype examined, 'Douglas' exhibited the highest anthocyanin content (89.55 mg/100 g), while 'Catskill' displayed the lowest anthocyanin content (65.88 mg/100 g). The highest total sugar content was observed in the Winter Dawn genotype (7.53 g), followed by Camarosa (7.40 g), Larson (6.88 g) and Jutogh Special (6.50 g). Conversely, the lowest sugar content was found in Fairfox variety (5.23 g), with Anthena closely behind (5.31 g). The reasons for variation may be due to difference in the growing condition, climatic variation and inherent nutrient condition of the genotypes Khammayom *et al.* (2022). Our findings are close in line with the findings of Jami *et al.* (2015) and Jan *et al.* (2021)

SUMMARY

The present study was carried during 2022–2023 at Punjab Agricultural University, Regional Research Station Bathinda, Punjab to identify superior strawberry genotypes based on morphological and biochemical traits. In the findings of the current investigation, it is evident that significant variations exist among the various strawberry genotypes. This diversity is attributed to a combination of environmental conditions and their interactions. Notably, the genotypes Camarosa, 'Douglas and Jutogh Special exhibit superior characteristics in terms of horticultural traits, particularly concerning fruit size, fruit weight, fruit number and fruit yield. However, in terms of biochemical traits, the genotype Winter Dawn has the highest TSS and total sugars, genotype Red Coat has the highest phenolics whereas maximum vitamin C was found in genotype Ofra. On the other hand, genotype Douglas gave maximum anthocyanin values. Overall, it is anticipated that the genotypes Winter Dawn, Camarosa, Douglas, and Jutogh Special are well-suited for sub-tropical conditions in Punjab concerning fruit quality. Consequently, the observed genetic diversity within the strawberry genotypes in the south-western region of Punjab holds promise for screening elite genotypes, thereby facilitating further advancements in breeding initiatives.

REFFERENCES

Dzhanfezova T, Gregorio Barba-Espín, Renate Muller, Bjarne Joernsgaard, Josefine Nymark Hegelund, Bjoern Madsen, Dorthe H Larsen, Mabel Martínez Vega and Torben Bo Toldam Andersen. 2020. Anthocyanin profile, antioxidant activity and total phenolic content of a strawberry (*Fragaria* × *ananassa* Duch) genetic resource collection. *Food Bioscience* **36**: 100620.

Gupta A. 2021. 'Morphological characterization of variability in strawberry (Fragaria × ananassa duch.) for DUS testing'. MSc Thesis, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India.

Hatami T, Emami S A, Miraghaee S S and Mojarrab. 2014. Total phenolic contents and antioxidant activities of different extracts and fractions from the aerial parts of *Artemisia biennis* wild. *The Iranian Journal of Pharmaceutical Research* **13**: 551–59.

Hussain M, Ismail M and Ali S. 2014. Quantitative determination of ascorbic acid in commercial fruit juices by redox titration. *The International Journal of Pharmaceutical Quality Assurance* **5**: 22–25.

Jami Y Y, Sarkar A and Maiti C S. 2015 Evaluation of strawberry cultivars in the foothills of Nagaland. *Journal of Crop and Weed* **11**: 198–113.

Jan S, Baba J A, Sharma M K, Qurat S, Wani T F, Nisar S, Angmo T, Shahzad D S and Kossar S. 2021. Evaluation of different strawberry cultivars for growth, yield and quality characters under temperate conditions of north-western Himalayas. *International Journal of Current Microbiology and Applied Sciences* **10**: 837–44.

Khammayom N, Maruyama N and Chaichana C. 2022. The effect of climatic parameters on strawberry production in a small walk-in greenhouse. *AgriEngineering* **4**: 104–21.

Kumar B, Kumar S and Yadav Y C. 2012. Genetic variability for some metric traits in strawberry (*Fragaria* × *ananassa* Duch.). The *Hort Flora* Research *Spectrum* **1**: 86–88.

Kumar U, Sonkar P and Dhakad A. 2020. Study on strawberry (*Fragaria* × *ananassa* Duch.) varieties for growth, fruit bio-chemical and yield parameters under western Malwa plateau conditions of Madhya Pradesh. *Journal of Pharmacy and Pharmacology* **9**: 1070–73.

Lee J, Durst R W and Wrolstad R E. 2005. Determination of total monomeric anthocyanin pigment content of fruit juices, beverages, natural colorants, and wines by the *p*H differential method: collaborative study. *The Journal of AOAC International* **88**: 1269–78.

Mathieu R G, Gaston A, Aïnouche A, Malika O, Klaus, Staudt G, Richard Land Denoyes B. 2009. Tracking the evolutionary history of polyploidy in *Fragaria* L. (strawberry): New insights from phylogenetic analyses of low-copy nuclear genes. *Molecular Phylogenetics and Evolution* **51**: 515–30.

Rahman S M L. 2011. 'Production technology of strawberry in Bangladesh'. PhD Thesis. Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur, Bangladesh.

Schwieterman M L, Colquhoun T A, Jaworski E A, Bartoshuk L M, Gilbert J L, Tieman D M, Odabasi A Z, Mosko H R, Witz K M, Folta H J, Whitaker V M and Clark D G. 2014. Strawberry flavour: Diverse chemical compositions, a seasonal influence and effects on sensory perception. *PloS One* **9**(2): e88446.

Singh R. 2016. 'Evaluation of strawberry (Fragaria × ananassa Duch.) cultivars under sub-tropical conditions of Punjab'. MSc Thesis, Punjab Agricultural University, Ludhiana, Punjab, India.

Tanuja and Rana D K. 2019. Efficacy of strawberry (Fragaria × ananassa Duch.) genotypes under valley condition of Garhwal Hills. *Plant Archives* **19**: 176–80.